INSTRUCTIONS

FOR USE

ARISTO STUDIO No. 868 No. 968

I. The Scales

The ARISTO Studio is a universal Log Log slide rule for scientists, engineers and students. With this class of users familiarity with elementary slide rule practice of the Rietz Pattern may be taken for granted. If necessary refer to our instructions for the ARISTO Technica or ARISTO Rietz models, or any standard literature on the subject.

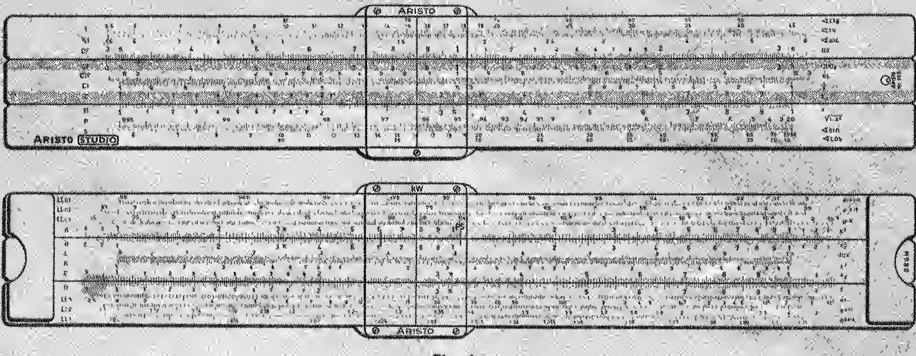


Fig. 1

Trigonometric Side:

Scale of Tangents and Cotangents	T	∢ tan	On body
		∢ cot	
Scale of Small Angles in Radians	ST	∢ arc	
Fundamental Scale folded by π	DF	πx	
Fundamental Scale folded by π	CF	πx	On slide
Reciprocal Scale folded by π	CIF....	$1/\pi x$	
Reciprocal Scale	CI.....	$1/x$	
Fundamental Scale	C	x	
Fundamental Scale	D	x	On body
Pythagorean Scale	P	$\sqrt{1-x^2}$	
Scale of Sines and Cosines	S......	∢ sin	
		∢ cos	

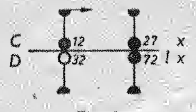
Log Log Side:

Log Log Scale, range:	.99 — .9	LL01 ..	$e^{-.01x}$	On body
	.91 — .35	LL02 ..	$e^{-.1x}$	
	.35 — .00001	LL03 ..	e^{-x}	
Scale of Squares		A	x^2	
Scale of Squares		B	x^2	On slide
Mantissa Scale		L	$\log x$	
Scale of Cubes		K	x^3	
Fundamental Scale		C	x	
Fundamental Scale		D	x	On body
Log Log Scale, range:	2.5 — 100000	LL3	e^{x}	
	1.1 — 3.0	LL2 ...	$e^{.1x}$	
	1.01 — 1.11	LL1 ...	$e^{.01x}$	

II. Explanation of Working Diagrams used in the Solution of Examples

The scales are represented by parallel lines bearing their designations both in the customary letters and in symbols.

The beginning of an operation is indicated by an empty circle and each following step by a black circle. The final answer is given with an exclamation mark. A crossed empty circle signifies a new setting of an intermediate result.



$$\frac{32}{12} \times 27 = 72$$

Fig. 2

The cursor is represented by a vertical line. Arrows show the order and direction of the successive settings. Two crossed dotted lines call for a reversal of the rule.

III. Calculation with the Folded Scales DF, CF and CIF

These scales are the exact copies of the fundamental scales C, D and CI, but are displaced in their relative arrangement by the value π so that the value 1 on the above three scales is found near the middle of the graduation and the value π at the beginning.

Tabulations avoiding resetting the slide

$$y = 29\,x$$

x	1.7	3.45	5.0	10
y	49.3	100	145	290

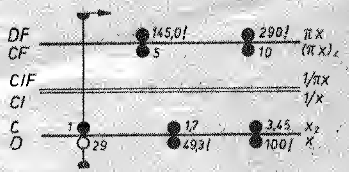


Fig. 3

$$y = \frac{28.2}{x} = 28.2 \times \frac{1}{x}$$

x	7.43	2.92	1.567
y	3.795	9.66	18.0

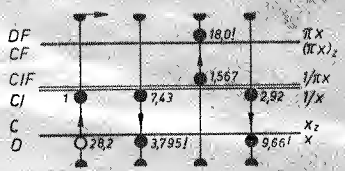


Fig. 4

$$y = \frac{x}{18.2} = \frac{1}{18.2} \times x$$

x	3.17	112.1
y	.1742	6.16

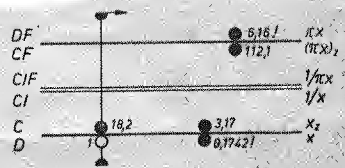


Fig. 5

Direct reading of multiplications and divisions involving π

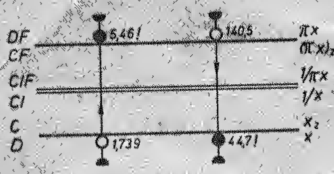


Fig. 6

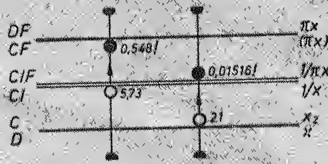


Fig. 7

$$1.739\,\pi = 5.46$$

$$\frac{140.5}{\pi} = 44.7$$

$$\frac{\pi}{5.73} = .548$$

$$\frac{1}{21 \times \pi} = .015\,16$$

IV. Pythagorean Scale P

For a right triangle having the hypotenuse 1 we have the following relation:

$$y = \sqrt{1 - x^2}$$

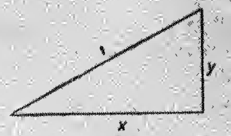


Fig. 8

For any setting x on the fundamental scale D we find the value y on scale P

Inversely: $x = \sqrt{1 - y^2}$

Example: $\sqrt{1 - .6^2} = .8$ $\qquad \sqrt{1 - .8^2} = .6$

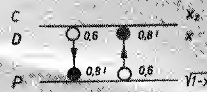


Fig. 9

Always take your readings where the highest degree of accuracy may be expected, for instance

$\sqrt{1 - .15^2} = .9887$ (here .15 is set on scale D).

An example in electrical engineering:

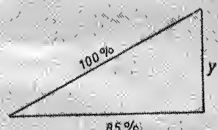


Fig. 10

Apparent load = 100%

Effective load = 85%

Wattless load $= \sqrt{1 - .85^2} = .527$, therefore 52.7%.

The Pythagorean Scale may be similarly applied in such cases where the hypotenuse is either .01, 1 or 100 etc. especially in changing from sine to cosine (e. g. $\sin\alpha = \sqrt{1 - \cos^2\alpha}$). For all other shapes of right triangles e. g. in problems involving vectors, complex numbers, coordinates etc. the trigonometric method is more elegant. (See Chapter VI.)

When the number whose root is wanted is near .01, 1 or 100 etc., greater accuracy is obtained by converting, for example: $\sqrt{.95} = \sqrt{1 - .05} = 0.9747$ (.05 is set on scale A).

V. Trigonometric Functions

All trigonometric functions are correlative to the scale D. Their values refer to a 360° circle with decimal subdivisions.

By using the following table the functions of any angle can be reduced to the first quadrant.

	$\pm\alpha$	$90^\circ \pm \alpha$	$180^\circ \pm \alpha$	$270^\circ \pm \alpha$	$45^\circ \pm \alpha$
sin	$\pm \sin\alpha$	$+\cos\alpha$	$\mp \sin\alpha$	$-\cos\alpha$	$\cos(45^\circ \mp \alpha)$
cos	$+\cos\alpha$	$\mp \sin\alpha$	$-\cos\alpha$	$\pm \sin\alpha$	$\sin(45^\circ \mp \alpha)$
tan	$\pm \tan\alpha$	$\mp \cot\alpha$	$\pm \tan\alpha$	$\mp \cot\alpha$	$\cot(45^\circ \mp \alpha)$
cot	$\pm \cot\alpha$	$\mp \tan\alpha$	$\pm \cot\alpha$	$\mp \tan\alpha$	$\tan(45^\circ \mp \alpha)$

$\sin 26^\circ = .438$

$\sin(-82^\circ) = -\sin 82^\circ$

$= -\sqrt{1-\cos^2 82^\circ} = -.9903$

arc sin .54 $= 32.7^\circ$, or 147.3° etc.

Always read **equal** colors!

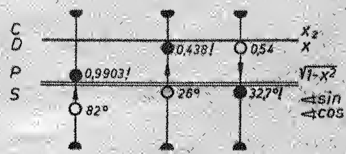


Fig. 11

$\cos 75^\circ = .2588$

$\cos 187^\circ = -\cos 7^\circ$

$= -\sqrt{1-\sin^2 7^\circ} = -.99255$

arc cos $(-.9852) = 170.13^\circ$, or 189.87° etc.

Always read **unequal** colors!

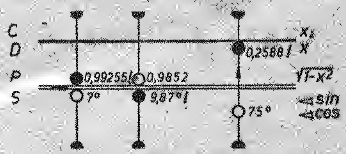


Fig. 12

$\tan 14^\circ = .2493$

$\tan 100^\circ = -\tan 80^\circ = -\frac{1}{\cot 80^\circ} = -5.67$

$\tan 100^\circ = -\cot 10^\circ = -5.67$

arc tan $1.75 = 60.25^\circ$, or 240.25° etc.

Always read **equal** colors!

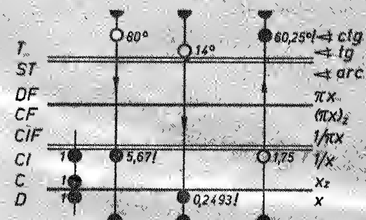


Fig. 13

$\cot 77^\circ = .2309$

$\cot(-9^\circ) = -\cot 9^\circ = -\frac{1}{\tan 9^\circ} = -6.31$

arc cot $2.0 = 26.57^\circ$, or 206.57° etc.

Always read **unequal** colors!

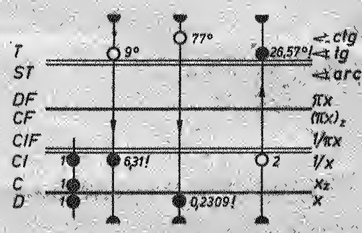


Fig. 14

The functions of small angles between .55° and 6° are found on scale ST. They are accurate for angles in radians and have to be regarded as good approximations where the sin and tan functions are concerned, in accordance with the formula:

$$\sin\alpha \approx \tan\alpha \approx \text{arc}\,\alpha = \frac{\pi}{180} \times \alpha \qquad \frac{\pi}{180} = .01745$$

Example: $\sin 1^\circ \approx \tan 1^\circ \approx \cos 89^\circ \approx \cot 89^\circ \approx \text{arc}\,1^\circ = \frac{\pi}{180} = .01745$ radians

$$\cot 1^\circ = \frac{1}{\tan 1^\circ} \approx \frac{180}{\pi} = 57.3 \text{ radians (on CI)}$$

The cosines of small angles and the sines of large angles cannot be computed directly with the slide rule. When these are involved the solution is by use of the series progression:

$$\cos\alpha \approx 1 - \frac{\alpha^2}{2} \ (\alpha \text{ in radians})$$

$$\cos 1^\circ \approx 1 - \frac{.01745^2}{2} = 1 - .000152 = .999848$$

Over the angle setting on scale ST the square of α in radians is immediately available on the scale A. To find the angle corresponding to a given cosine reverse the process.

The conformity between sin, tan, and arc is very good up to 4°. Angles between 4° and 6° are better computed with

$$\sin\alpha = \alpha^\circ \times \frac{\sin 6^\circ}{6} \text{ and } \tan\alpha = \alpha^\circ \times \frac{\tan 6^\circ}{6}$$

Conversion of Dregrees to Radians

Scale ST is a duplicate of the fundamental scale D, displaced laterally by the value $\frac{\pi}{180}$ relative to scale D. Therefore by following the cursor line from scale ST to D we achieve the conversion of degrees to radians, and vice versa. This form of calculation is applicable not only to the small angles above discussed but to large angles as well, by virtue of the decimal subdivision of the degrees.

Any setting of an angle α may also be regarded as representing .1 α, 10 α, 100 α etc. and the decimal point in the radian is then placed accordingly.

For instance: .1° = .001745 radians 10.0° = .1745 radians

The marks ϱ' and ϱ'' on scale C give the means of direct computations of radians, when minutes or seconds are given. They are derived from the conversion factors:

$$\varrho' = \frac{180}{\pi} \times 60 = 3438 \qquad \varrho'' = \frac{180}{\pi} \times 60 \times 60 = 206265$$

From the above it can be followed: $\text{arc}\,\alpha\ (\alpha \text{ in radians}) = \frac{\alpha'}{\varrho'} = \frac{\alpha''}{\varrho''}$

Example: $\text{arc}\,22' = \frac{22'}{\varrho'} = .00640$ radians

These marks are very convenient for calculations with small angles or arcs.

To find the angle: $\alpha = \frac{b}{r} \times \varrho$

To find the length of arc: $b = \frac{\alpha \times r}{\varrho}$

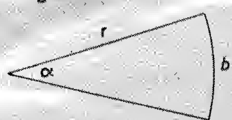


Fig. 15

VI. Trigonometric Computation of Right Triangles

For right triangles the law of sines states:

$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{1} = \frac{a}{\cos\beta} = \frac{b}{\cos\alpha}$$

and further: $\tan\alpha = \dfrac{a}{b}$

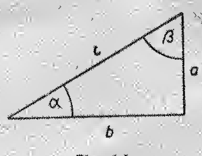


Fig. 16

With the aid of these relations one setting of the slide is sufficient for the solution of any right triangle. Depending on which of the elements are known, there are two fundamental calculating operations viz.:

1. Given any two parts (other than case 2)
2. Given the two sides a and b

Example for 1:

Given: $c = 5$, $a = 3$ Required: α, β, b. Remember that: $\beta = 90° - \alpha$

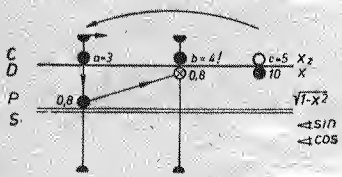


Fig. 17

or

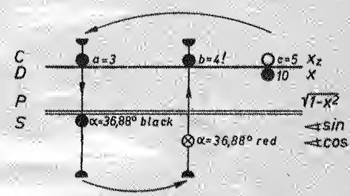


Fig. 18

Always begin with c set over right or left index of scale D. Fig. 17 and Fig. 18 show two possible solutions. To settle which method is best suited for a particular problem, examine on which scale the graduation is better readable in the region where the answer will appear and solve accordingly.

With one side and an angle known, the procedure is analogous i. e. the sine ratio of a given side and its opposite angle are set on scales C and S.

Example for 2:

Given: $a = 3$, $b = 4$

Required: α, β, c

$$\tan\alpha = \frac{3}{4} = 3 \times \frac{1}{4}$$

$$\alpha = 36.88°$$

$$c = \frac{a}{\sin\alpha} = \frac{3}{\sin 36.88°} = 5$$

After finding ∢ α on scale T, as shown in Fig. 19, the cursor is set over the same angle on scale S with slide unchanged. Now read $c = 5$ under the hairline on scale CI.

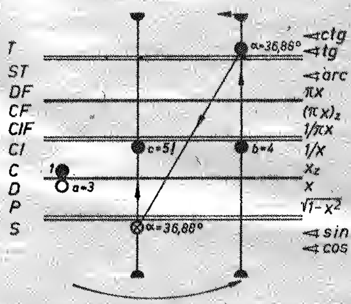


Fig. 19

Another example of the same kind of calculation:

Given: $a = 15$, $b = 25$

Solution: $\alpha = 30.96°$ $\beta = 90° - 30.96° = 59.04°$ $c = 29.16$

The two classes of solutions for right triangles discussed in the preceding text are of particular significance in problems involving coordinates, vectors, and complex numbers. Such problems invariably require conversions of rectangular coordinates to polar coordinates and vice versa.

A complex number can be written two ways: $Z = a + jb = r^{j\varphi} = r\underline{/\varphi}$

Examples for converting complex numbers: $Z = 4.5 + j\,1.3 = 4.68\,\underline{/16.13^\circ}$

$Z = 6.7\,\underline{/49^\circ} = 4.39 + j\,5.05$

The solution of these examples is shown in the explanation above.

VII. The Log Log Scales

All Log Log scales are in correlation to the fundamental scales C and D. The e^{-x} scales LL01, LL02, LL03 furnish the reciprocals of the e^{+x} scales LL1, LL2, LL3. Their range is from 1.01 to 100,000 for positive values of x and from .00001 to .99 for negative values of x.

Attention: The Log Log scales supply unequivocal the whole numbers or numbers with their fractional parts in decimals. This means that when we read 1.35 on the scale, this is the exclusive value concerned. It is not decimally variable as in dealing with the fundamental scales.

The 10th and 100th Powers and Roots

The exponential scales yield the tenth and hundredth powers or their roots in one setting of the cursor depending upon the direction of reading.

Fig. 20 shows several examples:

$$1.015^{10} = 1.1605$$
$$1.015^{100} = 4.43$$
$$1.015^{-100} = .2257 = 1/4.43$$
$$1.015^{-10} = .8617 = 1/1.1605$$
$$1.015^{-1} = .98522 = 1/1.1015$$

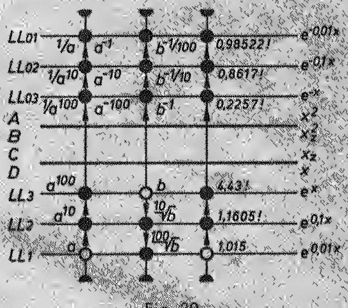


Fig. 20

Variations of readings in the same range of numbers:

$$\sqrt[10]{4.43} = 1.1605 \qquad .98522^{100} = .2257$$
$$\sqrt[100]{.2257} = .98522 \qquad \frac{1}{\sqrt[10]{4.43}} = .8617$$

These examples will seldom arise in practice and are only given with a view to facilitate understanding of the fundamental pattern governing the exponential scales.

VIII. Powers

In the same manner in which multiplication is effected on the fundamental scales, the Log Log scales are used for raising values to any power.

Procedure:

1. Set left end line of scale C over the base value "a" on the appropriate Log Log scale.
2. Set the exponent with cursor on scale C.
3. Read the value of the power under hairline of cursor on the appropriate Log Log scale.

Table for $y = 3.2^x$

$3.2^{2.5} = 18.3$	$3.2^{-.25} = .7476$
$3.2^{.25} = 1.338$	$3.2^{-.025} = .97134$
$3.2^{.025} = 1.02955$	$3.2^{3.1} = 36.8$
$3.2^{-2.5} = .0546$	$3.2^{.36} = 1.520$

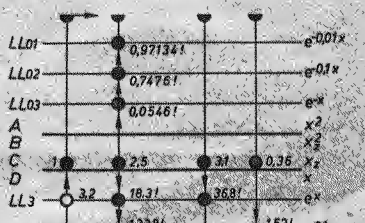


Fig. 21

It will be seen that one setting of the base gives a table of any of its powers.

Reading Rules:

1. For any positive exponent the reading is taken from the same group of scales LL1—LL3 or LL01—LL03 (equal colors). For any negative exponent we switch from one group of scales to the other (unequal colors).

2. When the exponent is varied by one decimal place to the left (as indicated by the symbols on the right margin of the rule) the reading is taken from that one of the scales LL1—LL3 or LL01—LL03 which has the next lower index digit. Obviously, we must read on the next higher one of these scales when the decimal point in the exponent is shifted to the right.

3. When setting the base with the right hand end line of the slide, all answers are read from the Log Log scale with the next higher index digit.

For $0 < a < 1$ find the powers with positive exponents on the three negative Log Log scales LL01—LL03 and those with negative exponents on the three positive Log Log scales LL1—LL3.

$$\left.\begin{aligned} .85^{3.25} &= .5896 \\ .85^{-3.25} &= 1.696 \end{aligned}\right\} \text{Fig. 22}$$

$$\left.\begin{aligned} 1.46^{2.7} &= 2.78 \\ 1.46^{-2.7} &= .36 \\ .685^{2.7} &= .36 \\ .685^{-2.7} &= 2.78 \end{aligned}\right\} \text{Fig. 23 and Fig. 24}$$

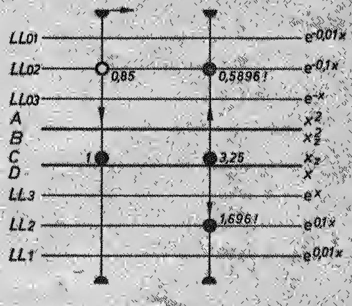


Fig. 22

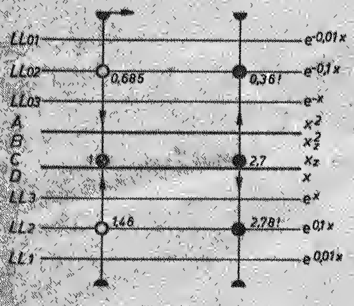


Fig. 23

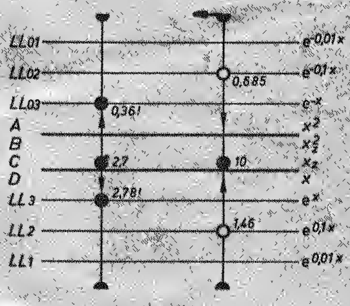


Fig. 24

$|x|$ very small

In conformity with the series expansion $e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \cdots\cdots$ the approximation $e^x \approx 1 + x$ is applicable when small exponents are involved.

After deducting the 1 in the formula, the fundamental scale may be regarded as the continuation of the Log Log scales. Reverting to the tabulation for $y = 3.2^x$ (page 8), we find, by reading on scale D under the same cursor line the value 2908, that

$$3.2^{.0025} = 1 + .002908 = 1.002908$$
$$3.2^{-.0025} = 1 - .002908 = .997092$$

Further decimal variations in the exponent merely effect a corresponding change in the number of zeros or nines after the decimal point. So, for instance:

$$3.2^{.00025} = 1.0002908$$

$0.99 < a < 1.01$

In deeling with values of this range, which are omitted from the graduations of the Log Log scales, we can again use the fundamental scale D as if it were an exponential scale. The base is resolved into $1 \pm x$ and the left index of the slide aligned to the value x on the fundamental scale D. The powers are then obtained in customary manner, switching to the exponential scales as and when required.

Approximation for small values of x: $a^n = (1 \pm x)^n \approx 1 \pm n \times x$

Examples:

$1.0023^{3.7} = (1 + .0023)^{3.7} \approx 1 + .00851 \approx 1.00851$	Read on scale D and add 1
$1.0023^{37} = (1 + .0023)^{37} \approx 1.0888$	Read on scale LL1
$.9977^{3.7} = (1 - .0023)^{3.7} \approx 1 - .00851 \approx .99149$	Read on scale D and deduct from 1
$.9977^{37} = (1 - .0023)^{37} \approx .9183$	Read on scale LL 01

A higher degree of precision is obtainable by substituting:

$$\ln(1 + x) \approx x \times \left(1 - \frac{x}{2}\right)$$ when setting the base on scale D

$$e^x \approx 1 + x \times \left(1 + \frac{x}{2}\right)$$ when reading the result of the power on scale D

Example: $1.0023^{3.7} \approx (1 + .0023 \times .99885)^{3.7} \approx 1.00227^{3.7} \approx 1 + 3.7 \times .00227 \approx$
$1.00850 \approx 1 + .00850 \times 1.00425 \approx 1.00854$

Powers of the base e

The equation $y = e^x$ is applicable when the index of the slide is set to base e or, the scales C and D now being in coincidence, we find any power of the base e by moving the cursor to the exponent on scale D. In Fig. 20 all values of the body scales correspond to settings of the exponent **1.489** and its decimal variations.

$e^{1.489} = 4.43$	$e^{-1.489} = .2257$
$e^{.1489} = 1.1605$	$e^{-.1489} = .8617$
$e^{.01489} = 1.015$	$e^{-.01489} = .98522$

IX. Roots

Radical expressions are often better understood and easier handled when they are reduced to expressions of powers, thus:

$$\sqrt[3.5]{e} = e^{\frac{1}{3.5}} = 1.3307$$

This work is best done with the reciprocal scale CI.

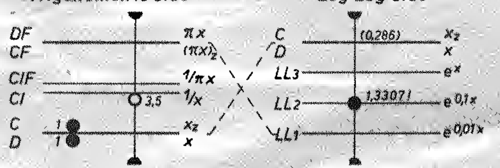


Fig. 25

In the same manner in which divisions are performed with the fundamental scales, the Log Log scales are available for extracting roots. Since $y = a^x$ accordingly $\sqrt[x]{y} = a$.

Procedure:

1. Opposite the radicand y on Log Log scale set the radical index x on fundamental scale C.
2. Read the root under either left or right end line of slide on the corresponding Log Log scale.

The reading rules on p. 9 are adaptable to this case. It should be noted, however, that when the answer appears under the right extreme of the slide, we read on the next lower labeled scale LL1—LL3 or LL01—LL03.

$$\sqrt[.77]{21} = 52.1 \qquad \frac{1}{\sqrt[.77]{21}} = .0192$$

$$\sqrt[7.7]{21} = 1.485 \qquad \frac{1}{\sqrt[7.7]{21}} = .6734$$

$$\sqrt[77]{21} = 1.0403 \qquad \frac{1}{\sqrt[77]{21}} = .96122$$

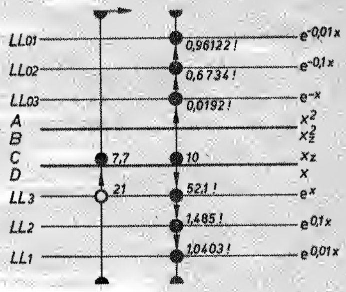


Fig. 26

X. Logarithms

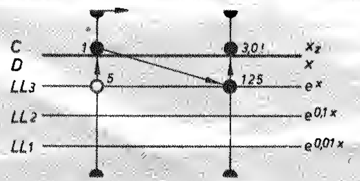
With the Log Log scales all logarithms can be determined. By reversing the process of raising to a power, we determine the logarithm:

$y = a^x \qquad x = \log_a y$ (read logarithm of y to the base a)

The finding of a logarithm is thus identical to a problem of powers in which the exponent is sought.

Procedure:

1. Set left end line of fundamental scale C over base value "a" on the appropriate Log Log scale.
2. Set hairline of cursor over the antilog y on the Log Log scale.
3. Read the logarithm under hairline of cursor on scale C.



$$\log_5 125 = 3.0$$

Fig. 27

The decadal logarithms to the base 10 can be found in the same manner by setting the end line of scale C to the base on scale LL3. The decadal logarithms can also be obtained from the customary mantissa scale on the slide.

$$\log_{10} 1.920 = .2833$$

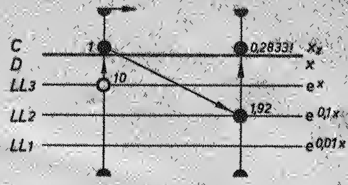


Fig. 28

The natural logarithms to the base e can be read direct on scale D.

$$\log_e 1.06 = .0583$$

$$\log_e 1.27 = .239$$

$$\log_e 4.5 = 1.504$$

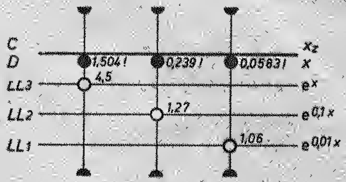


Fig. 29

Locating the decimal point is explained by the consideration that

$$\log_a a = 1$$

With the left end line of the slide over the base "a" all values to the right of the value "a" on scale C are greater than 1 and all values to the left of "a" on scale C are smaller than 1.

Reading Rules:

1. Passing from one Log Log scale to the adjacent scale — in the order LL 3, LL 2, LL 1 or LL 03, LL 02, LL 01 — signifies a shift of the decimal point in the logarithm by one place to the left and, in the reverse order, by one point to the right.

2. The logarithms assume positive (negative) values when their antilogs and bases are set on equal-colored (unequal-colored) Log Log scales.

$$\log_{10} 50 = 1.699$$

$$\log_{10} 2 = .3010$$

$$\log_{10} 1.03 = .01283$$

$$\log_{10} .015 = -1.824$$

$$\log_{10} .5 = -.3010$$

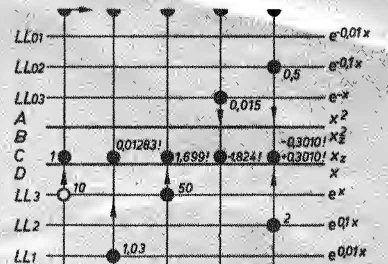


Fig. 30

When the slide is pushed out extending to left of the body, all readings are taken from left of the base value. Since these values are < 1, the decimal point must logically be moved one place to the left as compared with the examples in Fig. 30.

Examples:

$\log_{10} 6 = .778$	$\log_2 16 = 4.0$	$\log_{.25} 2 = -.5$
$\log_{10} 1.14 = .0569$	$\log_2 1.02 = .02857$	$\log_e .05 = -3.0$
$\log_{10} 1.015 = .00647$	$\log_2 .25 = -2$	$\log_e .622 = -.475$

XI. Other Applications of the Log Log Scales

The slide of the Log Log side of the rule contains not only the fundamental scale C and the scale of squares B, but also the mantissa scale L and the scale of cubes K. Its usefulness is, therefore, not restricted to operations involving x^2, x^3, $\sqrt{x}$, $\sqrt[3]{x}$ and $\log_{10} x$ but is extended to powers of the shapes $a^{\sqrt{x}}$, $a^{\sqrt[3]{x}}$ a^{10^x} as well as, inversely, to logarithms of the shapes $\log_a^2 x$, $\log_a^3 x$, $\log_{10} \log_a x$.

The folded scales DF, CF and CIF can also be used in combination with the Log Log scales to avoid resetting of the slide.

Solving Proportions with the Log Log Scales

When the slide index is set to some base value of "a" on a Log Log scale, powers to any exponent and logarithms to any number of this base can be obtained.

The base "a", when set on the Log Log scale, can therefore be regarded as one of the terms in a proportion.

$$y_1 = a^n \qquad , \qquad y_2 = a^m$$

$$\log y_1 = n \times \log a \qquad \log y_2 = m \times \log a$$

$$\frac{\log a}{1} = \frac{\log y_1}{n} = \frac{\log y_2}{m}$$

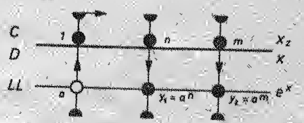


Fig. 31

$$y = a^{\frac{m}{n}} \quad \rightarrow \quad \frac{\log y}{m} = \frac{\log a}{n}$$

$$y = 4.3^{\frac{6.8}{2.7}} \quad \rightarrow \quad \frac{\log y}{6.8} = \frac{\log 4.3}{2.7} \quad \rightarrow \quad y = 39.4$$

After setting 4.3 on scale LL 3 opposite 2.7 on C, the result 39.4 will be found under 6.8 of C on the LL 3 scale. Modifications of this problem are, of course, solved analogously.

The formulas of many laws in natural sciences can be suitably arranged to permit of solution in the manner discussed above when the change in one variable is proportional to the logarithm of the ratio of the other variable.

$$\log \frac{y_2}{y_1} = \text{const} \times (x_2 - x_1)$$

Any mutation of x_1 to x_2 by the interval i entails a change of y_1 to y_2. When the ratio $\frac{y_2}{y_1}$ is given the designation r, i. e. the rest of the original whole quantity, the above equation can be written

$$\frac{\log r}{i} = \text{const} = \frac{\log r_1}{i_1} = \frac{\log r_2}{i_2} = \ldots$$

Example: Radioactive Decay

A substance is known to disintegrate at the rate of 40% in 30 days, leaving a residue of 60%. $i_1 = 30$, $r_1 = .60$.

After how many days will 20% be left? $\frac{\log .6}{30} = \frac{\log .2}{x} \quad \rightarrow \quad x = 94.5$ days.

The logarithms are set on the Log Log scales.

For multiplication of a constant factor and a logarithm the constant on C is set opposite to the base of the logarithm on the Log Log scale. Thus a tabulating position is obtained.

$$2 \times \log_{10} 100 = 4$$

$$2 \times \log_{10} 1.8 = .511$$

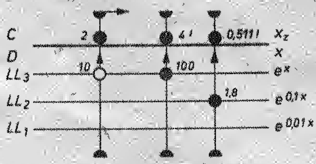


Fig. 32

Hyperbolic Functions

The unique construction of the Log Log scale system enables the formation of hyperbolic functions, e. g.

$$\sinh x = \frac{e^x - e^{-x}}{2} \qquad \cosh x = \frac{e^x + e^{-x}}{2}$$

The values of e^x and e^{-x} can be obtained by one setting of the cursor.

XII. The Detachable Cursor and its Lines

The hairlines of the two cursor windows are precisely matched so that the user can pass from one face of rule to the other when required in the course of a problem. The accuracy oft his adjustment is not disturbed when the cursor is taken off for cleaning. To remove the cursor, use both thumbs to press the tips of the bar marked with arrows in downward direction. This releases the snap-fastener and the cursor can be taken off the slide rule (Fig. 33).

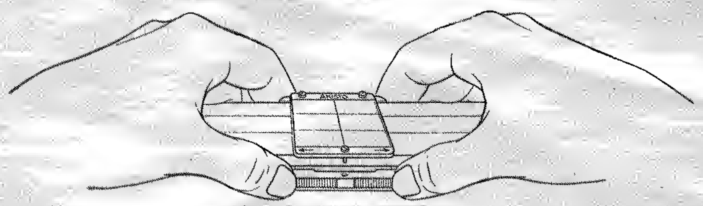


Fig. 33

The Mark 36

The front face of the cursor contains a short line to the right of the center line and on level with the folded scales (Fig. 34). The lateral distance of this line from the center line corresponds to the factor 36 for readings on scale DF relative to any setting on the fundamental scale D. By virtue of this arrangement the cursor can be used for conversions of:

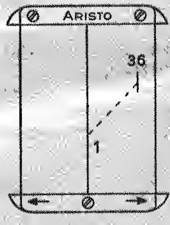


Fig. 34

Years to Days:	1 year = 360 days
Hours to Seconds:	1 hour = 3600 seconds
	1 meter per second = 3.6 kilometers per hour
Degrees to Seconds:	1° = 3600″

The Marks for Circle Areas

The intervals between the upper left or the lower right line on the one hand and the center line on the other hand amount to $\frac{\pi}{4} = .785$ i. e. the constant applicable in computations of circle areas or round sections $A = d^2 \times \frac{\pi}{4}$ (Fig. 35). To find any required circular area, set the lower right or the center hairline to the given diameter d on scale D and read the area under the center line or the upper left line, respectively, on scale A.

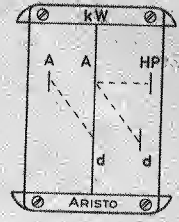


Fig. 35

The Marks KW and HP

The interval between the upper right line and the center line is equivalent to the coefficient .746, applicable to conversions of HP to kW (Fig. 35). Hence, when the center hairline is set to 20 kW, for example, on the scale of squares, then the upper right line indicates the equivalent in HP viz. 26.8. Inversely, when the short right line is set to 7 HP the center line will produce the equivalent: 5.22 kW.

XIII. Treatment of the ARISTO Slide Rule

The instrument is a valuable calculating aid and deserves careful treatment. Scales and cursor should be protected from dirt and scratches, so that the reading accuracy may not suffer.

It is advisable to give the rule an occasional treatment with the special cleanser fluid DEPAROL, or with soap and water followed by a dry polishing. Avoid chemical substances of any description as they are almost certain to spoil the scales.

Do not leave the rule on heated surfaces such as radiators. Do not expose for a greater length of time to powerful sunlight. Deformations may occur in temperatures above 60°C (140°F). Rules so damaged will not be exchanged free of charge.

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Aristo

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SCALES

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